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The Accounting of the Transverse Slides for the Layered Composites

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Abstract

The primary issues of an advanced mechanics, which are contemporary twisted, inflexible bodies, are the issues identified with ideal planning of structures. The significance and innovation of that issue are controlled by both hypothetical importance of the issue and their logical intrigue. As it is outstanding that the most powerless spots for the layered composites are the association between the layers where it isolates from one another amid distortion. That is the reason upon comparison of classical theory with adjusted theory with transverse slides accounting the latter is always preferred.

Keywords: Composite materials; Beam; Displacement; Rotation; Equilibrium; Contemporary deformed; Transverse slides; Cylindrical bending; Stability

Introduction

It is the simplest and admitted model of the transverse slides [1]. (Figure 1)

$$u_x = u + z\varphi;\ u_y = v + z\psi;\ u_z = w \qquad (1)$$

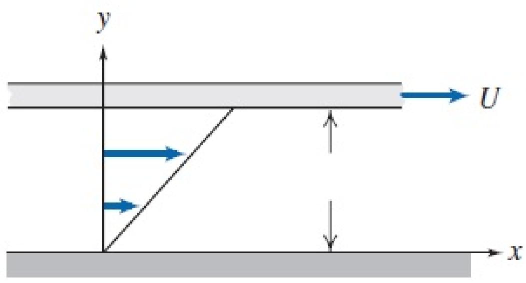

Figure 1: Simple picture.

With such setting the efforts and moments of the plate will have the following form* [2]:

$$T_x = C_{11}\frac{\partial u}{\partial x} + C_{12}\frac{\partial v}{\partial y},\ T_y = C_{12}\frac{\partial u}{\partial x} + C_{22}\frac{\partial v}{\partial y},\ T_{xy} = C_{66}\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) \qquad (2)$$

$$M_x = D_{11}\frac{\partial \varphi}{\partial x} + D_{12}\frac{\partial \psi}{\partial y},\ M_y = D_{12}\frac{\partial \varphi}{\partial x} + D_{22}\frac{\partial \psi}{\partial y},\ M_{xy} = D_{66}\left(\frac{\partial \varphi}{\partial y} + \frac{\partial \psi}{\partial x}\right) \qquad (3)$$

$$N_x = 2nhA_{44}\left(\varphi + \frac{\partial w}{\partial x}\right),\ C_{44} = 2nhA_{44};\ N_y = 2nhA_{55}\left(\psi + \frac{\partial w}{\partial y}\right),\ C_{55} = 2nhA_{55}$$

*It is already admitted that besides $D_{16} = D_{26} = 0$ we also have $C_{16} = C_{26} = 0;\ C_{ij} = 2h\sum_{k=1}^{n} B_{ij}^{(k)}$ [3].

Selling of the Problem

The problem is at rectangular plate stability, when on two opposite sides equally distributed efforts act ρ [4].

The critical effort in this care will be determined from the following system [5]:

$$\begin{aligned}
&D_{44}\left(\frac{\partial \varphi}{\partial x} + \frac{\partial^2 w}{\partial x^2}\right) + D_{55}\left(\frac{\partial \psi}{\partial y} + \frac{\partial^2 w}{\partial y^2}\right) - \rho\left(\frac{\partial^2 w}{\partial x}\right) = 0\\
&D_{11}\left(\frac{\partial^2 \varphi}{\partial x^2}\right) + D_{66}\left(\frac{\partial^2 \varphi}{\partial y^2}\right) + \left(D_{12} + D_{66}\right)\frac{\partial^2 \psi}{\partial x \partial y} = D_{44}\left(\varphi + \frac{\partial w}{\partial x}\right)\\
&\left(D_{12} + D_{66}\right)\frac{\partial^2 \varphi}{\partial x \partial y} + D_{66}\left(\frac{\partial^2 \varphi}{\partial x^2}\right) + D_{22}\left(\frac{\partial^2 \psi}{\partial y}\right) = D_{55}\left(\psi + \frac{\partial w}{\partial y}\right)
\end{aligned} \qquad (4)$$

The analogous conditions of the simple joint will be [6]:

$$W = \frac{\partial^2 w}{\partial x^2} = \frac{\partial \varphi}{\partial x} = 0$$

$$W = \frac{\partial^2 w}{\partial y^2} = \frac{\partial \psi}{\partial y} = 0$$

For the sought functions satisfying these conditions we shall have [7]:

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$$w = w_{mn} sin\lambda_m x \quad sin\mu_n y$$
$$\varphi = \varphi_{mn} cos\lambda_m x \quad sin\mu_n y \qquad (6)$$
$$\psi = \psi_{mn} sin\lambda_m x \quad cos\mu_n y$$

$$\lambda_m = \frac{m\pi}{a}, \mu_n = \frac{n\pi}{b}$$

For definite a and b relations the critical effort will be determined by the following formula [8]:

$$\rho\lambda_m^{\ 2} = D_{44}\lambda^2 + D_{55}\mu^2 + \frac{\Delta 1}{\Delta} \qquad (7)$$

Where,

$$\Delta_1 = 2C_{44}C_{55}\lambda_m^{\ 2}\mu_n^{\ 2} + (D_{12} + D_{66}) -$$
$$C_{44}^{\ 2}\lambda_m^{\ 2}(D_{22}\ \ \mu_n^{\ 2} + D_{66}\lambda_m^{\ 2} + C_{55}) \qquad (8)$$
$$-D_{55}^{\ 2}\mu_n^{\ 2}(D_{11}\lambda_m^{\ 2} + D_{66}\mu_n^{\ 2} + D_{44})$$

$$\Delta = D_{11}D_{66}\lambda_m^{\ 4} + D_{22}D_{66}\mu_n^{\ 4} -$$
$$(D_{11}D_{22} - D_{12}^{\ 2} - 2D_{12}D_{66})\lambda_m^{\ 2}\mu_n^{\ 2} +$$
$$C_{44}(D_{22}\mu_n^{\ 2} + D_{66}\lambda_m^{\ 2}) + C_{55}(D_{11}\lambda_m^{\ 2} + D_{66}\mu_n^{\ 2})$$

The simplest solution is obtained for one-dimensional (cylindrical bending) problem [9]:

$$C_{44}\left(\frac{\partial\varphi}{\partial x} + \frac{\partial^2 w}{\partial x^2}\right) + P\left(\frac{\partial^2 w}{\partial x^2}\right) = 0 \qquad (9)$$

$$D_{11}\frac{\partial^2\varphi}{\partial x^2} = C_{44}\left(\varphi + \frac{\partial w}{\partial x}\right)$$

For the considered boundary conditions the critical effort in this care will be:

$$P_{kp} = D_{11}\lambda_1^{\ 2}\left(1 - \frac{D_{11}}{C_{44}}\lambda_1^{\ 2}\right) \qquad (10)$$

From here it can be seen that when $C_{44} \to \infty$ we obtain classical $P_{kp} = D_{11}\lambda_1^{\ 2}$ result and that the transverse slide accounting brings to the minimizations of the critical effort [10]. It in the considered problem the primary state is smoothly stressed, and then now we consider a problem when the primary state is momental [11]. Patricianly, we consider the problem on testability of a layered plate, when on its external surfaces oppositely directed stresses of S intensively act [12]. In this care the only of font coming from the primary state will be transverse

$$N_1^{\ 0} = S.H,\ H = 2nh \qquad (11)$$

And the equations of the stability will have the form:

$$C_{11}\left(\frac{\partial^2 u}{\partial x^2}\right) + C_{66}\frac{\partial^2 u}{\partial y^2} + (C_{12} + C_{66})\frac{\partial^2 v}{\partial x\partial y} + SH = 0$$
$$(C_{11} + C_{66})\frac{\partial^2 u}{\partial x\partial y} + C_{66}\left(\frac{\partial^2 v}{\partial x^2}\right) + C_{22}\left(\frac{\partial^2 v}{\partial y^2}\right) + SH = 0$$
$$C_{44}\left(\frac{\partial\varphi}{\partial x} + \frac{\partial^2 w}{\partial x^2}\right) + C_{55}\left(\frac{\partial\psi}{\partial y} + \frac{\partial^2 w}{\partial y^2}\right) = 0$$
$$SH\frac{\partial u}{\partial x} + C_{44}\left(\varphi + \frac{\partial w}{\partial x}\right) - D_{11}\left(\frac{\partial^2\varphi}{\partial x^2}\right) - D_{66}\left(\frac{\partial^2\varphi}{\partial y^2}\right) - \qquad (12)$$
$$(D_{12} + D_{66})\frac{\partial^2\varphi}{\partial x\partial y} = 0$$
$$SH\frac{\partial v}{\partial x} + C_{55}\left(\psi + \frac{\partial w}{\partial y}\right) - (D_{12} + D_{66})\frac{\partial^2\varphi}{\partial x\partial y} -$$
$$D_{66}\left(\frac{\partial^2\psi}{\partial x^2}\right) - D_{22}\left(\frac{\partial^2\psi}{\partial y^2}\right) = 0$$

For the freely supported plate:

$$u = u_{mn} sin\lambda_m x \quad sin\mu_n y$$
$$v = v_{mn} cos\lambda_m x \quad sin\mu_n y$$
$$w = w_{mn} sin\lambda_m x \quad cos\mu_n y \qquad (13)$$
$$\varphi = \varphi_{mn} cos\lambda_m x \quad sin\mu_n y$$
$$\psi = \psi_{mn} sin\lambda_m x \quad cos\mu_n y$$

The critical effort will be determined by the following condition [13]:

$$\det\|a_{ij}\| = 0 \qquad (14)$$

Where

$$a_{11} = -C_{11}\lambda^2 - C_{66}\mu^2,\ a_{12} = a_{21} = (C_{12} + C_{66})\lambda^2\mu^2$$
$$a_{41} = a_{14} = -SH = -a_{25} = -a_{52},\ a_{22} = -C_{22}\mu^2 - C_{66}\lambda^2$$
$$a_{33} = -C_{55}\mu^2 - C_{44}\lambda^2,\ a_{43} = a_{34} = -C_{44}\lambda \qquad (15)$$
$$a_{35} = a_{55} = -C_{55}\mu,\ a_{44} = -(C_{44} + D_{11}\lambda^2 + D_{66}\mu^2)$$
$$a_{45} = a_{54} = (D_{12} + D_{66})\lambda\mu,\ a_{55} = -(C_{55} + D_{66}\lambda^2 - D_{22}\mu^2)$$

Conclusion

The rest of coefficient are equal to zero and in the last expressions for shortness on and magnitudes index has not been set.

As in the previous problem let's consider the care of the cylinder bending:

$$C_{11}\frac{\partial^2 u}{\partial x^2} + SH\frac{\partial \varphi}{\partial x} = 0$$

$$C_{44}\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial \varphi}{\partial x}\right) = 0 \qquad (16)$$

$$SH\frac{\partial u}{\partial x} + C_{44}\left(\frac{\partial w}{\partial x} + \varphi\right) - D_{11}\left(\frac{\partial^2 \varphi}{\partial x^2}\right) = 0$$

The critical effort will be determined by the following formula:

$$Sh = \pm\sqrt{C_{11}D_{11}\lambda_1}$$

In fact in one-dimensional problem the transverse sliders accounting does not change the value of the classic one.

Suggested Technology has some Advantages

- It has a optimization system;
- It is cheaper;
- Getting a high qualitative production;

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